NBS MISC. PUBL. 260-15

Standard Reference Materials:

RECOMMENDED METHOD OF USE OF STANDARD LIGHT-SENSITIVE PAPER FOR CALIBRATING CARBON ARCS USED IN TESTING TEXTILES FOR COLORFASTNESS TO LIGHT

U.S. Department of Commerce
National Bureau of Standards

THE NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] provides measurement and technical information services essential to the efficiency and effectiveness of the work of the Nation's scientists and engineers. The Bureau serves also as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To accomplish this mission, the Bureau is organized into three institutes covering broad program areas of research and services:

THE INSTITUTE FOR BASIC STANDARDS . . . provides the central basis within the United States for a complete and consistent system of physical measurements, coordinates that system with the measurement systems of other nations, and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. This Institute comprises a series of divisions, each serving a classical subject matter area:

—Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic Physics—Physical Chemistry—Radiation Physics—Laboratory Astrophysics[2]—Radio Standards Laboratory,[2] which includes Radio Standards Physics and Radio Standards Engineering—Office of Standard Reference Data.

THE INSTITUTE FOR MATERIALS RESEARCH . . . conducts materials research and provides associated materials services including mainly reference materials and data on the properties of materials. Beyond its direct interest to the Nation's scientists and engineers, this Institute yields services which are essential to the advancement of technology in industry and commerce. This Institute is organized primarily by technical fields:

—Analytical Chemistry—Metallurgy—Reactor Radiations—Polymers—Inorganic Materials—Cryogenics[2]—Office of Standard Reference Materials.

THE INSTITUTE FOR APPLIED TECHNOLOGY . . . provides technical services to promote the use of available technology and to facilitate technological innovation in industry and government. The principal elements of this Institute are:

—Building Research—Electronic Instrumentation—Technical Analysis—Center for Computer Sciences and Technology—Textile and Apparel Technology Center—Office of Weights and Measures —Office of Engineering Standards Services—Office of Invention and Innovation—Office of Vehicle Systems Research—Clearinghouse for Federal Scientific and Technical Information[3]—Materials Evaluation Laboratory—NBS/GSA Testing Laboratory.

---

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C., 20234.

[2] Located at Boulder, Colorado, 80302.

[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

UNITED STATES DEPARTMENT OF COMMERCE • Alexander B. Trowbridge, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Standard Reference Materials:

Recommended Method of Use of Standard Light-Sensitive Paper for Calibrating Carbon Arcs Used in Testing Textiles for Colorfastness to Light

Elio Passaglia and Paul J. Shouse

Institute for Materials Research
National Bureau of Standards
Washington, D.C.

National Bureau of Standards Miscellaneous Publication 260–15

Issued July 21, 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 20 cents

PREFACE

Within the framework of the NBS Institute for Materials Research the area of standard reference materials is a broad and important one, including the preparation, characterization and distribution of a wide variety of materials in such diverse fields as metallurgy, polymers and inorganic materials. In carrying out such a program there is much interaction with representatives of industry and science, beginning with discussions as to which primary standard materials will do most to advance technology, the furnishing of materials and fabrication of samples, and the characterization and certification of the materials by cooperative efforts. The many groups participating in a standards program are very interested in detailed information on specific aspects of the program -- but to date there has been no publication outlet for such written discussions.

To meet this need, NBS Miscellaneous Publication 260 has been reserved for a series of papers in the general area of "standard reference materials". This series will present the results of studies and investigations undertaken within the Institute for Materials Research with emphasis on the preparation and characterization of standard reference materials. This subject-oriented series will provide a means for rapid dissemination of this detailed information and we hope will stimulate the use of standard reference materials in science and industry.

W. Wayne Meinke, Chief
Office of Standard Reference Materials

OTHER NBS PUBLICATIONS IN THIS SERIES

NBS Misc. Publ. 260, Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, October 1965. 45 cents.* (Supersedes NBS Misc. Publ. 241, March 1962.)

NBS Misc. Publ. 260-1, Standard Reference Materials: Preparation of NBS White Cast Iron Spectrochemical Standards, June 1964. 30 cents.*

NBS Misc. Publ. 260-2, Standard Reference Materials: Preparation of NBS Copper-Base Spectrochemical Standards, October 1964. 35 cents.*

NBS Misc. Publ. 260-3, Standard Reference Materials: Metallographic Characterization of an NBS Spectrometric Low-Alloy Steel Standard, October 1964. 20 cents.*

NBS Misc. Publ. 260-4, Standard Reference Materials: Sources of Information on Standard Reference Materials, February 1965. 20 cents.*

NBS Misc. Publ. 260-5, Standard Reference Materials: Accuracy of Solution X-Ray Spectrometric Analysis of Copper-Base Alloys, March 1965. 25 cents.*

NBS Misc. Publ. 260-6, Standard Reference Materials: Methods for the Chemical Analysis of White Cast Iron Standards, July 1965. 45 cents.*

NBS Misc. Publ. 260-7, Standard Reference Materials: Methods for the Chemical Analysis of NBS Copper-Base Spectrochemical Standards, October 1965. 60 cents.*

NBS Misc. Publ. 260-8, Standard Reference Materials: Analysis of Uranium Concentrates at the National Bureau of Standards December 1965. 55 cents.*

NBS Misc. Publ. 260-9, Standard Reference Materials: Half Lives of Materials Used in the Preparation of Standard Reference Materials of Nineteen Radioactive Nuclides Issued by the National Bureau of Standards, November 1965. 15 cents.*

NBS Misc. Publ. 260-10, Standard Reference Materials: Homogeneity Characterization of NBS Spectrometric Standards II: Cartridge Brass and Low-Alloy Steel, December 1965. 30 cents.*

NBS Misc. Publ. 260-11, Standard Reference Materials: Viscosity of a Standard Lead-Silica Glass. November 1966. 25 cents.*

NBS Misc. Publ. 260-12, Standard Reference Materials: Homogeneity Characterization of NBS Spectrometric Standards III: White Cast Iron and Stainless Steel Powder Compact. September 1966. 20 cents.*

NBS Misc. Publ. 260-13, Standard Reference Materials: Mossbauer Spectroscopy Standard for Chemical Shift of Iron Compounds. (In press.)

NBS Misc. Publ. 260-14, Standard Reference Materials: Determination of Oxygen in Ferrous Materials SRM 1090, 1091, and 1092. September 1966. 30 cents.*

*Send orders with remittance to: Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Remittance from foreign countries should include an additional one-fourth of the purchase price for postage.

TABLE OF CONTENTS

RECOMMENDED METHOD OF USE OF STANDARD LIGHT-SENSITIVE PAPER FOR CALIBRATING CARBON ARCS USED IN TESTING TEXTILES FOR COLORFASTNESS TO LIGHT

Elio Passaglia and Paul J. Shouse
Institute for Materials Research
National Bureau of Standards
Washington, D.C. 20234

ABSTRACT

The use of NBS Light-Sensitive Paper and NBS Booklets of Standard Faded Strips in the standardization of fading lamps is described. These lamps are used to determine the fading characteristics of textiles, and the light-sensitive paper is thus useful in standardizing this procedure.

Key words: Light-Sensitive Paper; Booklets of Faded Strips; Fading Characteristics; Textiles; Fading Standardization.

1. INTRODUCTION

Light Sensitive Paper

Standard light-sensitive paper (NBS Standard Reference Material 700b) and booklets of standard faded strips of this paper (NBS Standard Reference Material 701b) are sold by the National Bureau of Standards for use in standardizing the dosage of the radiant energy of commercial carbon-arc lamps especially those used for testing textiles for colorfastness to light. These lamps vary in radiant output from one to another and from time to time. The lack of duplicability in their performance must be taken into consideration in using them. The paper may be used to check the performance of lamps in order to predict the number of clock hours of exposure that will be required to produce fading corresponding to a specified number of Standard Fading Hours. The more frequently such checks are made the greater will be the assurance that the lamp is performing satisfactorily.

The paper was made in the National Bureau of Standards paper mill and was dyed with the direct azo dye, Benzo Azurine G, Colour Index No. 24140. The dyed paper is supplied in pieces 2-5/8 inches by 3-1/4 inches.

The booklets contain six strips of the paper 1-1/2 inches wide that have been faded by exposure in the National Bureau of Standards Master Lamp [1] in amounts corresponding to stated numbers of "Standard Fading Hours" of exposure between 7 and 25. Twenty "Standard Fading Hours" of exposure is approximately equivalent in fading action to 20 clock hours of exposure in the well-known Atlas Electric Devices Company's FDA-R Fade-Ometer, based upon the average

results of tests in one hundred and thirty of these lamps.

The paper and booklets make it possible to translate clock hours of exposure in lamps to "Standard Fading Hours" (SFH) and thus to express the dosage of radiant energy on a common basis.

Given the same current, voltage, other electrical operating conditions, and similar carbons, the radiant flux emitted by the carbon-arc fading lamp is assumed to be reasonably under control with respect to spectral distribution. The use of the light-sensitive paper is intended to correct for moderate variations in radiant flux.

NBS Standard Lamp

The Master Lamp at NBS is an Atlas Electric Devices Type SMC-R enclosed carbon arc Fade-Ometer operated on alternating current and uses No. 70 solid carbons and No. 20 cored carbons. The solid carbon is placed in the upper holder and the cored carbon in the lower holder for one run, and these positions are reversed for the next run.

The arc is enclosed with a special Pyrex glass globe No. 9200 PX. The lamp is operated at a black panel temperature of 150 $\pm$ 5 °F (66 $\pm$ 3 °C) measured on the sample rack, and at a relative humidity of approximately 30%, and air temperature of approximately 116 $\pm$ 1 °F (47 $\pm$ 0.5 °C), both measured at the point where the air leaves the test chamber. The sample rack is 20 inches in diameter, and rotates at approximately 3 rpm [1].

Commercial fading lamps usually provide some control of temperature and relative humidity of the air about the specimens. The method of the American Association of Tex-

265-522 O - 67 - 2

tile Chemists and Colorists calls for exposure of specimens in filtered air of 30% relative humidity. The recommended temperature, measured with a special black panel thermometer facing the arc, is 145 ± 5 °F (63 ± 3 °C) [2].

2. EXPOSURE OF PAPERS

Limitations of Papers

The many factors that may affect the duplicability of results in testing textiles for colorfastness to light make such tests difficult to repeat. Some of the factors that the operator of a fading lamp should keep in mind include: density and spectral distribution of the incident radiant flux, the temperature and relative humidity of the air at the specimen, atmospheric contamination, method of mounting the specimen, and intermittent exposure. These factors affect the fading of the paper as well as textiles, but the magnitude of the effects may not only be different for paper and textiles but also for different textiles. The relative rates of fading of different textiles and the paper will not necessarily change to the same degree with changes in these conditions.

Exposures made on the 30-in diameter sample rack of a Weather-Ometer, using No. 20 and No. 70 carbons, will probably be much lower than are those obtained on the 20-in diameter rack of the NBS Master Lamp, and the above factors will not be applicable. Also, the necessity of turning the Weather-Ometer spray off during exposures produces conditions that are not representative of normal Weather-Ometer operating conditions.

Similarly, because of differences in spectral distribution and intensity of the carbon arc, exposures made with another type lamp such as a Xenon lamp, S-1 Sun lamp, or fluoroescent lamp, will be quite different from the exposures of the Master Lamp, and the reflectance versus Standard Fading Hour curve shown in the attached figure will not apply. The paper has been calibrated only for carbon arc Fade-Ometers.

The paper and some textiles fade more in a given time if exposed intermittently than if exposed continuously, perhaps because of an increase in moisture content while the lamp is shut off and more rapid fading when it is turned on again. It is therefore desirable to begin tests with a fresh set of carbons in the lamp and to avoid shutdowns.

Procedure for Exposure

Mount a piece of the unexposed paper in a specimen holder of the lamp in the usual way (without backing) and place it in the lamp at the time it is started with a new set of carbons. Expose the paper continuously for 20 hours. Remove it and allow it to stand in the dark at room temperature for at least 2 hours in order for it to cool and to come to equilibrium with the moisture in the air. If the fading is to be judged only visually, trim off and discard the unexposed edges of the paper and of the strips in the booklets as they may affect the judgment of the fading. For instrumental measurements the edges should remain attached for enhanced ease of handling during the measurements.

Some variations in exposure may be encountered at different positions around the sample rack. A more representative value for the lamp may therefore be obtained by filling the circumference of the rack with paper in the lower portion of the type CD-LSR holder when it is mounted on a rack where it is held at only one elevation with respect to the arc. On other types of racks, the paper should be held at an elevation as near the level of the center of the arc as possible and at sample distance from it. From these exposures an average value for the lamp may be obtained. The paper should be placed in the holders so that the portion to be exposed is not backed by printed matter on the other side of the paper. This could seriously affect the results, especially if reflectance measurements are made.

The practice in some laboratories of mounting specimens on black or white cardboard or other backing has an effect on fading especially of thin translucent specimens, and therefore the backing used should be noted in reporting the results of tests. As already indicated, the light-sensitive paper should be exposed without backing as the SFH scale is based upon its use in this way. For strict control, the paper and textile should be put in the lamp at the same time and in comparable positions; for instance, both in the upper or lower row, and any vacant positions in the lamp should be filled with dummy specimens to reduce variations in air currents and reflections.

3. RATING OF THE PAPERS AFTER EXPOSURE

Visual Estimation

Compare the fading of the exposed paper with that of the standard faded strips in the booklet. To do this, hold the booklet in one hand, allow the pages to flip open one after another, rear cover first, and slip the exposed paper under one standard faded strip after another, being careful to have the standard strip superimposed closely upon the exposed paper and with the long dimension of the two papers in the same direction. Make the comparison in the light from a daylight fluorescent lamp, or equivalent source, with illumination of 50 foot candles or more on the papers. The lamp should be parallel to the long edge of the paper and booklet. The incident light should strike the paper at an angle of 45°, and the angle of viewing should be perpendicular to the surface of the paper. Avoid touching the surfaces of the exposed paper and the standard strips with the fingers, as they are sensitive to moisture and soil easily.

From the comparison, estimate the exposure in Standard Fading Hours that would duplicate the fading of the test piece. Obtain a factor for converting clock hours of exposure in the machine to Standard Fading Hours. For example, if the paper exposed for 20 clock hours faded to an extent considered to fall half way between the 16 and 20 SFH strips in the booklet, i.e., 18 SFH, the factor would be 18/20 or 0.9. Credit textiles exposed in the machine for a given number of clock hours with an exposure in Standard Fading Hours of 0.9 times the clock hours.

If the factor is greater than 1.1, the fading rate of the lamp is considered too high. The lamp should then be adjusted to a slower fading rate.

The lamp calibration outlined in the preceding paragraphs is a suitable basis for timing exposures in routine testing. For more precise testing, however, the dosage of radiant energy should be measured with the paper during each test, as the fading rate of a lamp may change from day to day and even during a test. The procedure is illustrated by the following directions for control of a 20-hour exposure.

Place the textile specimen and two (or more if desired) pieces of the paper in the lamp at the same time, side by side. Remove one of the papers from the lamp about 4 hours before the estimated end of the test, noting the time. Allow this paper to stand in the dark at room temperature for 2 hours; compare the fading with that of the standard faded strips; and obtain the factor for converting clock hours to SFH as already outlined. Use this factor in calculating the time of exposure for the textile under test. The piece of paper left in the lamp with the textile will have received the same radiant-energy exposure as the textile at the end of the test. The actual exposure in SFH at the end of the test will then be obtained by rating the fading of this paper with the standard faded strips in the booklet. The result can be used as evidence that the test was satisfactory or that it must be repeated.

For long exposures, a succession of papers will have to be used and the number of Standard Fading Hours shown by them added together to obtain the total exposure. In

carrying out such tests the paper should be changed with each change of carbons.

In making preliminary comparisons of faded papers and standard faded strips, it is permissible to breathe on the faded paper momentarily to increase its moisture content. Final comparisons should be made as already indicated, or better, after conditioning the paper in the dark by exposure to air at 50% relative humidity overnight or longer.

Measurement of Fading by Reflectance

Although the paper and booklets are designed for simple visual estimation of the fading without the use of any instruments, reflectance measurements with any one of several different instruments may be used. This is done regularly at the National Bureau of Standards in evaluating the faded strips that go into the booklets.

The specimens are conditioned in the dark by exposure to air having a relative humidity of 50 $\pm$ 4% and temperature of 73.5 $\pm$ 2 °F (23 $\pm$ 1 °C) for not less than 16 hours. The number of SFH corresponding to the reflectances of the papers in the booklets sold by the NBS falls within one-half Standard Fading Hour of that indicated in the booklet. The fading curve for light-sensitive paper, Standard Reference Material 700b, and limits of reflectance of the faded pieces in a typical booklet are shown in the attached figure. The papers may change in reflectance from exposure to air of lower or higher relative humidity, or temperature, light, soiling, and mishandling.

Reflectance measurements on different instruments sometimes show appreciable variation even when measuring

the same piece of exposed paper. Variation in reflectance readings can be caused by such things as differences in in linearity of photometric scales, spectral sensitivity of the photocell, spectral transmittance of filters, geometry of incident and viewing light beams, and differences in the plaques used to standardize the instruments. To minimize discrepancies attributable to measuring instruments, users should construct a fading curve for the light-sensitive paper, based on reflectance measurements with their own particular instrument, as described later.

To minimize instrument error, an additional package of unexposed paper should be obtained and set aside for standardization use. Protect the paper from light, dust, and excessive heat. Unexposed paper, Standard Reference Material 700b, has been found to have an average luminous reflectance factor Y of 0.1611.

To standardize the instrument, set it to read luminous reflectance factor Y for daylight with the green tristimulus filter. Place a piece of unexposed paper on the instrument and set the instrument to read 0.1611.

An alternative method of standardization, which may be better because it provides standardization at a level of reflectance more nearly that of the exposed papers measured, would be to use one of the papers in the booklet of standard faded strips for a standard, and to set the instrument at the value of reflectance written on the paper. In order to avoid using paper regularly for standardizing the instrument, read the value of a porcelain plaque (preferably of about the same reflectance) relative to that of the unexposed paper or relative to the booklet paper

used as a standard. From then on, the plaque can be used for setting the instrument scale by using the Y value thus obtained. Most accurate results will be obtained if the spectral reflectance of the plaque is nearly the same as that of the paper. With the instrument thus standardized the papers in the booklet should be measured and a fading curve established for the instrument. For most consistent results make all measurements with the grain of the paper in the same direction. The procedure is as follows:

1. Record the reading of $45^{\circ}0^{\circ}$ luminous-directional reflectance factor Y written on the face of each strip of paper in the booklet.

2. Read the corresponding value of SFH from the table, or from the curve constructed from this table. Linear interpolation may be used.

3. Measure luminous reflectance factor Y of each of these strips on the same instrument that is to be used to measure faded strips from the Fade-Ometer.

4. Plot a curve of the measured value of luminous reflectance relative to actual values of SFH determined above to provide a fading curve for the user's reflectometers.

Some reflectometers have a measurement precision that permits reflectance to be read to four figures, as indicated on the curve and in the table. Reflectance measurements, however, are probably accurate to no better than about 0.002 or roughly to $\pm$ 1 SFH at the upper end of the fading scale and to $\pm$ 0.6 SFH at the lower end.

4. PROCEDURE FOR ORDERING PAPER AND BOOKLETS

Different issues of the light-sensitive paper have different fading rates, and the booklets of standard faded strips and the fading curve supplied for any one issue of unexposed paper apply to that issue only; therefore booklets and unexposed paper of the same issue should be used together. The lower case letter at the end of the standard sample number indicates the issue of the standard sample. The booklet of standard fading strips No. 701b should be used with unexposed paper No. 700b. It cannot be used with No. 700a or any earlier issue of the paper. However, when the supply of unexposed paper No. 700b at NBS becomes exhausted, a new issue will be supplied as Standard Reference Material 700c. It will then become necessary for the customer to order a new booklet of standard faded strips No. 701c to be used with the new issue of paper. This is unavoidable because it is not possible at present to control the manufacture of the paper so that all of the issues of paper are exactly the same with regard to fading rate.

The unexposed paper cannot be used satisfactorily without the booklet of standard faded strips because of differences in measuring instruments, as outlined earlier. This publication, explaining the use of the paper and booklet, accompanies each order for a booklet of standard faded strips or paper. However, it will be sent separately, free, on request. Order by Standard Reference Material number (700b for the unexposed paper; 701b for the booklet of standard faded strips.) Address orders to

Office of Standard Reference Materials
National Bureau of Standards
Washington, D.C. 20234
Attention: Standard Reference Materials Unit

Prices and terms of purchase are given in NBS Miscellaneous Publication 260, "Catalog and Price List of Standard Reference Materials Issued by the National Bureau of Standards."

5. REFERENCES

[1] The original master lamp described in NBS Research Paper RP1916, (J. Res. NBS 41, 169-177, 1948) has been replaced by an Atlas Electric Devices Company Fade-Ometer, type SMC-R with glass-enclosed arc operating on 15-17 amperes, 120-145 volts alternating current.

[2] 1966 Technical Manual of the American Association of Textile Chemists and Colorists 42, Standard Test Method 16A-1964, AATCC, National Headquarters, Research Triangle Park, P.O. Box 886, Durham, North Carolina 27702.

TABLE OF LUMINOUS REFLECTANCE FACTOR Y AS MEASURED
ON A GARDNER-TYPE COLOR-DIFFERENCE METER MODEL C-1 vs SFH
FOR LIGHT-SENSITIVE PAPER

STANDARD SAMPLE NO. 700b

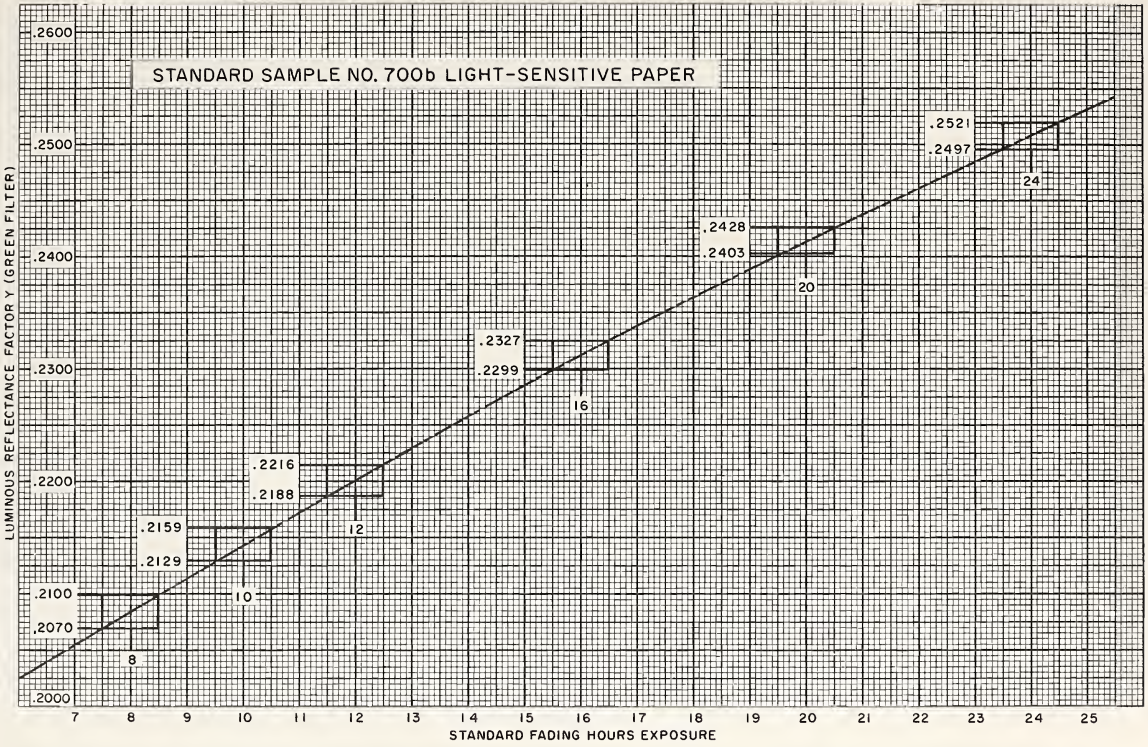
SFH	Y	SFH	Y	SFH	Y
6.5	.2040	13.0	.2230	19.5	.2403
7.0	.2056	13.5	.2244	20.0	.2415
7.5	.2070	14.0	.2258	20.5	.2428
8.0	.2084	14.5	.2272	21.0	.2439
8.5	.2100	15.0	.2285	21.5	.2452
9.0	.2114	15.5	.2299	22.0	.2463
9.5	.2129	16.0	.2313	22.5	.2475
10.0	.2144	16.5	.2327	23.0	.2486
10.5	.2159	17.0	.2339	23.5	.2497
11.0	.2173	17.5	.2351	24.0	.2509
11.5	.2188	18.0	.2365	24.5	.2521
12.0	.2201	18.5	.2378	25.0	.2532
12.5	.2216	19.0	.2390	25.5	.2544

To facilitate assembling the booklets, a paper whose reflectance falls exactly on a 1/2 SFH point is given to the next whole SFH higher. For example, if a paper happens to have a reflectance value of .2403 it is designated 20 SFH in the booklet; likewise, .2327 the value for 16.5 SFH is designated 17 SFH.

The booklets of standard faded strips are made in three series as follows:

7 - 9 - 11 - 15 - 19 - 23 SFH
8 - 10 - 12 - 16 - 20 - 24 SFH
9 - 11 - 13 - 17 - 21 - 25 SFH

This was done for ease in visual judgment, and to facilitate production. These booklets are considered to be equivalent, and the one that a customer receives depends on what is available at that time.



Luminous reflectance factor Y (green filter) versus standard fading hours exposure for Standard Sample No. 700b Light-Sensitive Paper.

U. S. GOVERNMENT PRINTING OFFICE: 1967 O - 265-522

Announcement of New Publications on

Standard Reference Materials

Superintendent of Documents
Government Printing Office
Washington, D. C. 20402

Dear Sir:

Please add my name to the announcement list of new publications to be issued in the series: NBS Miscellaneous Publication 260 - Standard Reference Materials.

Name _____

Company _____

Address _____

City _____ State _____ Zip Code _____

(Notification key N-330)

U.S. DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20230

OFFICIAL BUSINESS

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE